
HONEY AS A NEUTRACEUTICAL : A Review

ABSTRACT

Honey has been revered not only as a natural sweetener but also for its numerous health benefits. This chapter delves into honey as a nutraceutical, exploring its multifaceted role in promoting health and preventing disease. Nutraceuticals, defined as products derived from food sources with extra health benefits in addition to their basic nutritional value, have gained significant attention in recent years. Honey stands out due to its rich composition of bioactive compounds, including flavonoids, phenolic acids, vitamins, minerals, and enzymes. The therapeutic properties of honey are attributed to its antioxidant, anti-inflammatory, antimicrobial, and wound-healing capabilities. This chapter provides a comprehensive review of scientific studies that highlight the efficacy of honey in various medical applications, such as treating infections, enhancing immune function, and managing chronic diseases like diabetes and cardiovascular disorders. Additionally, we discuss the mechanisms through which honey exerts its beneficial effects, emphasizing its role in modulating oxidative stress and inflammatory pathways. In conclusion, honey, with its profound nutraceutical properties, offers a natural and holistic approach to health and wellness. This chapter aims to provide valuable insights for researchers, healthcare professionals, and consumers interested in the therapeutic potential of honey and its applications in modern medicine.

Keywords: Nutraceutical, Honey, Bioactive Compounds

Introduction

1. NEUTRACEUTICAL

The word "nutraceutical" comes from the combination of the words "nutrition" and "pharmaceutical". Nutraceuticals refer to products that are derived from food, but are used in pill, capsule, powder or other unconventional forms as food, and are claimed to have health or medical benefits. Nutraceutical products may include dietary supplements, fortified or enriched foods, or functional food products designed to support specific bodily functions, promote health, prevent chronic disease, or affect body structure or function.

Nutraceuticals can be divided into several categories, including:

- a. Nutrients: Substances that provide nutrients, such as vitamins, minerals, amino acids, and fatty acids.
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- b. Herbal/natural products: Products that contain extracts or ingredients from plants, often used for health or medicinal purposes.
- c. Dietary supplements: Products used to supplement the diet by increasing total nutrient intake.

The benefits of nutraceuticals are often supported by scientific research showing how certain active ingredients can provide health benefits. However, it is important to note that nutraceutical health claims should be taken with caution and ideally under the supervision of a healthcare professional, as product efficacy and safety can vary, and regulation of nutraceutical products can differ between countries. Nutraceuticals play an important role in supporting and improving the health of the human body. They cover a wide range of products derived from food sources that not only provide nutritional value but also offer additional health benefits, including disease prevention and management of health conditions.

By providing bioactives, vitamins, minerals, and other essential nutrients, nutraceuticals contribute to various aspects of the body's health:

1.1 Improved Immune Function

Nutraceuticals rich in antioxidants, such as vitamin C, vitamin E, and beta-carotene, can help strengthen the immune system. They protect cells from damage by free radicals, which can lead to inflammation and various chronic diseases. Honey has long been known to have benefits in boosting the body's immune function. Several studies highlight that honey, including kelulut honey, can provide benefits to health and the immune system (Lestariningsih et al., 2022). Honey has been identified as having antioxidant, anti-inflammatory, and probiotic properties that can help boost the immune system. In addition, honey can also help in increasing the body's resistance to infection, including in pandemic situations such as COVID-19 (Hossain et al., 2022).

1.2 Heart Health

Many nutraceuticals contain omega-3 fatty acids, plant sterols, and soluble fiber that have been shown to lower LDL (bad) cholesterol levels and increase HDL (good) cholesterol. This helps maintain cardiovascular health and reduces the risk of coronary heart disease. Honey plays an important role in the heart as a cardioprotective. Consuming honey can minimize the risk of heart problems. This is because honey can increase plasma lipids, suppress oxidation, attenuate the increase in markers of heart damage, catalyze antioxidant activity and can increase the resistance of LDL (low-density lipoprotein) to oxidative stress oxidation in heart disease (Idrus et al., 2020).

1.3 Weight and Metabolism Management

Some nutraceuticals can support weight management and a healthy metabolism. For example, soluble fiber helps control appetite and improve digestion, while certain compounds such as capsaicin (found in chili peppers) may increase calorie burning. In some research Rafie et al. (2018) and Gohar et al., (2020), honey has anti-obesity effects. The active components of honey, such as phenols and flavonoids, are thought to alter fat metabolism by increasing lipolysis and preventing lipogenesis (Ugusman et al., 2022).

1.4 Digestive Health

Nutraceuticals such as probiotics and prebiotics are essential for maintaining a balanced gut microbiome. They support digestive health, aid in nutrient absorption, and may protect against digestive disorders. Honey has various benefits for digestive health due to its high propolis content, which is an important factor in providing health benefits and disease therapy (Saputra et al., 2022). In addition, honey can also help in healing stomach wounds. The combination of prebiotic and probiotic foods, such as those found in honey, can help to improve digestive function (Mamuaja & Gumolung, 2018). Honey also has a gastroprotective effect that can promote healing of gastric ulcers (Pratiwi, 2020). The high sugar content in honey can inhibit microbial growth, which also contributes to digestive health (Puspita et al., 2018). In addition, rambutan honey contains substances that can stimulate cells through specific molecular structures to reduce oxidative stress, which is important for digestive health (Yuslianti et al., 2023).

1.5 Bone Health

Vitamin D and calcium are examples of nutraceuticals that support bone health and prevent conditions such as osteoporosis. Honey helps in the formation and maintenance of healthy bone structure. Honey, especially kelulut honey, has been known to have diverse health benefits, including for bone health. Kelulut honey is high in calcium, phosphorus, potassium, and Vitamin C, making it suitable for consumption by children, pregnant women, and the elderly who need natural supplements to maintain bone health (Hakim et al., 2021). Studies have also shown that stem cell therapy, which can be found in honey, has regeneration potential for orthopedic cases, including injuries to the bones (Wien Aryana & Febyan, 2023). This suggests that honey, with its stem cell content, may provide additional benefits in the process of bone healing and regeneration.

1.6 Chronic Disease Prevention and Management

Nutraceuticals have a role in the prevention and management of chronic diseases such as diabetes, hypertension, and some cancers. For example, nutraceuticals rich in fiber and antioxidants can help regulate blood sugar levels and offer protection against oxidative stress. Honey has long been known to

have a variety of health benefits, including in the prevention of diabetes, hypertension, and some cancers. The use of honey has been shown to be beneficial in the treatment of chronic wounds in patients with diabetes mellitus, as honey has anti-inflammatory, antibacterial, antioxidant properties, and is able to accelerate the wound healing process (Fuadi & Yanto, 2022). In addition, honey can also help in the prevention of hypertension, especially through non-pharmacological therapy and education on the prevention of hypertension (Ainurrafiq et al., 2019). Nutrients in honey, such as flavonoids and zinc, also contribute to disease prevention. Flavonoids in honey act as antioxidants that can help cell regeneration in wounds, while zinc content in dark-colored honey can prevent stunted growth in children, improve glucose absorption, and reduce the risk of liver disease (Yuslianti et al., 2023). Propolis can also be used as the best emulgator media in skin cancer therapy which is effective in inducing the apoptosis process (Puspaningrum et al, 2023).

1.7 Mental and Cognitive Health

Omega-3 fatty acids, flavonoids, and other nutraceuticals have been shown to support brain health, including improving cognitive function and possibly reducing the risk of mood disorders such as depression. Honey has an important role in human mental and cognitive health. Studies have shown that honey, especially certain types of honey such as manuka honey and tualang honey, has anti-inflammatory, anti-anxiety, and anti-depressant properties (Azman et al., 2015). Honey also contains phenol compounds and antioxidants that can protect the brain and improve cognitive function (Azman et al., 2021). It is important to remember that although nutraceuticals offer many health benefits, they should not be used as a substitute for a balanced diet and healthy lifestyle. It is always wise to consult a healthcare professional before starting a nutraceutical supplement, especially if you have certain health conditions or are taking other medications.

Honey is recognized as one of the most ancient and natural examples of a nutraceutical, known not only for its nutritional value but also for its extensive health benefits. As a nutraceutical, honey contains a variety of essential nutrients, including vitamins, minerals, enzymes, antioxidants, and phytochemical compounds that can contribute to the improvement of health and prevention of various health conditions.

2. COMPONENTS AND BENEFITS OF HONEY

Honey is rich in antioxidants, such as flavonoids and phenolics, which can protect the body from cell damage caused by free radicals. These antioxidants can help reduce the risk of chronic diseases such as heart disease and some

types of cancer. The antioxidants in honey play an important role in its health benefits. Honey, especially the kind that comes from certain flowers, contains a variety of antioxidants, including flavonoids, phenolics, ascorbic acid (vitamin C), enzymes such as glucose oxidase, and compounds such as amino acids and proteins. The content of these antioxidants may vary depending on the type of flowers visited by the bees, environmental conditions, and the honey processing process.

2.1 Benefits of Antioxidants in Honey

2.1.1 Protection against Cell Damage

Antioxidants protect body cells from damage caused by free radicals. Free radicals are unstable molecules that can cause cell damage and contribute to the aging process and the development of chronic diseases such as heart disease, diabetes, and cancer. In addition, honey has also been shown to have a positive effect on fibroblast cells, which are important in the wound healing process. Research shows that honey can enhance the migration and differentiation ability of fibroblast cells, which are an important model in wound research (Rahmah Aprilia et al., (2019). In addition, honey also has antimicrobial power that can protect cells from bacterial, fungal, and viral attacks (Yuliana et al., 2019).

2.1.2 Heart Health

Studies have shown that the antioxidants in honey may help lower the risk of heart disease by improving arterial health. For example, honey may help improve blood flow and prevent blood clots, which may reduce the risk of heart attack and stroke. Consuming honey can reduce the risk of heart disease because it can improve plasma lipids, suppress oxidation, attenuate the increase in markers of heart damage, catalyze antioxidant activity, and increase LDL resistance to oxidative stress oxidation (Idrus et al., 2020).

2.1.3 Stronger Immune System

The antioxidants in honey also support the immune system. By protecting immune cells from oxidative damage, honey can help boost the immune response to infection and disease. Honey has antioxidant, anti-inflammatory, and probiotic properties that can boost the immune system. They can also increase the body's resistance to infection (Hossain et al., 2020).

2.1.4 Digestive Health

Honey has a prebiotic effect, which means that it can support the growth of good bacteria in the gut. The antioxidants in honey may also help reduce inflammation in the digestive tract, supporting overall digestive health. Honey and foods

containing prebiotics and probiotics can improve digestive function. Its high sugar content can stop microbial growth, which helps maintain digestive health (Mamuaja & Gumolung, 2018).

2.1.5 Reduction of Inflammation

The antioxidant content in honey can help reduce inflammation throughout the body. Chronic inflammation has been linked to a variety of diseases, including heart disease, diabetes, and cancer. Honey has anti-inflammatory, antibacterial, and antioxidant properties, which can speed up the wound healing process. Honey can also help heal stomach wounds (Fuadi & Yanto, 2022).

3. THERAPEUTIC AND FUNCTIONAL APPLICATIONS OF HONEY

3.1 Consume Honey for Antioxidant Benefits

3.1.1 Consume Raw Honey : Raw honey is more likely to contain higher levels of antioxidants compared to honey that has been processed or pasteurized, as heat can reduce its antioxidant content.

3.1.2 Integration in Diet : Add honey to tea, yogurt, or smoothies to enrich your diet with natural antioxidants.

3.1.3 Selection of Honey Type : Some types of honey, such as manuka, **honeydew** or buckwheat honey, are known to have higher antioxidant content compared to other types of honey.

3.1.4 Antibacterial and Antimicrobial Properties

hydrogen peroxide content and low pH, honey has strong antibacterial and antimicrobial properties. This makes it effective in treating wounds and infections, as well as supporting skin health. Honey's antibacterial and antimicrobial properties are among its most valued health benefits and have been used since ancient times to treat a variety of conditions, including wounds and bacterial infections. These properties stem from the unique combination of several chemical and physical factors present in honey:

3.1.4.1 Hydrogen Peroxide

Honey produces hydrogen peroxide naturally through the activity of the enzyme glucose oxidase that bees add to nectar. Hydrogen peroxide acts as an effective antimicrobial agent, helping to clean wounds and prevent infection. Honey is known to have antiviral effects due to the content of hydrogen peroxide, flavonoids, and phenolic acids that are virucidal. The hydrogen peroxide content in honey also provides antibacterial activity with the ability to degrade bacterial DNA (Salsabila et al., 2022)..

3.1.4.2 High Sugar Content

The largest sugar components in honey are glucose and fructose, reaching 80% (Pamuncak et al., 2023). The high sugar concentration in honey draws water out

of microbial cells through osmosis, which inhibits bacterial growth and reproduction. Reduced sugar content in honey also has a significant impact. found that the higher the concentration of acid used in the biomass hydrolysis process, the higher the reduced sugar content (Agustini & Febrian, 2019). In addition, research by showed that high antioxidant activity was found in the treatment of sugar type in the form of honey (Nur Hasanah et al., 2019).

3.1.4.3 Low pH

Honey has a low pH (usually between 3.2 and 4.5), which creates an acidic environment that does not favor the growth of many bacteria. Honey has been shown to have strong antibacterial properties, and the low pH of honey creates an environment that does not favor the growth of bacteria (Lomban et al., 2021). Bacteria will grow in a pH 6.5 environment. Besides being able to inhibit bacteria, it is also known to inhibit the growth of fungi. The low pH in honey gives it a slightly sour taste and helps to enhance the flavor of honey (Primandasari et al., 2021). Other studies have also shown that the low pH in honey, along with its high free acid content, can aid in the wound healing process. The direct mechanisms of low pH in honey include the formation of hydrogen peroxide, high osmolality, and non-peroxide factors that all contribute to antibacterial and wound-healing properties (Putri & Asparini, 2017). The utilization of this low pH can be used as an environmentally friendly sanitizer product and provide other effects in addition to the antimicrobial properties of propolis (Susilo et al, 2024).

3.1.4.4 Bioactive Compound

Honey contains additional bioactive compounds such as flavonoids and other phenolics that have antibacterial properties. The type and quantity of these compounds can vary depending on the floral origin of the nectar. Honey contains a number of bioactive components such as polyphenols (phenolic acids and flavonoids), vitamin C, vitamin E, and enzymes that have antioxidant properties (Yuslianti et al., 2023). The high phenolic compounds in honey can be seen based on the color of the honey, namely the darker the color of the honey can indicate that the honey has high phenolic compounds (Hidayat et al., 2021). Volatile compound groups are present in a small part in honey obtained from the composition of nectar taken by bees, such as hydrocarbons, acids, ketones, alcohols, aldehydes, amines and oximes (Pamuncak et al., 2023). In addition, honey also contains bioactive peptides that can support the body's health functions. These bioactive components give honey strong antibacterial properties, so it can help inhibit bacterial growth in burn wounds and accelerate the healing process (Putri & Asparini, 2017).

3.1.4.5 Methylglyoxal (MGO)

Specifically in Manuka honey, Methylglyoxal (MGO) is a compound that has strong antimicrobial activity. The concentration of MGO in Manuka honey can be much higher than other types of honey, giving it stronger antibacterial properties. Research shows that methylglyoxal is one of the active compounds in honey that has antibacterial properties against Methicillin-Resistant *Staphylococcus aureus* (MRSA) (Salsabila et al., 2022).. This compound works together with other antibacterial components in honey, such as hydrogen peroxide, methyl syringate, and leptosperin, to inhibit the growth of antibiotic-resistant bacteria.

3.2 Clinical and Ethnomedicinal Implementation Of Honey

3.2.1 Treatment of Wounds and Burns : Honey is used topically to cleanse wounds, promote healing, and prevent infection. This is an accepted practice in modern medicine, especially with the development of honey-based wound care products that have been sterilized and approved for medical use (Putri & Asparini, 2017).

3.2.2. In vitro antibacterial activity of honey

In short review were summarized a recent data for in vitro antibacterial activity and perspectives for immunological studies in aspects of investigations for specific antibacterial activity substances in mixes between royal jelly and some kinds of bee honey. This could be important for future development of effective therapeutic agents for therapy of intestinal and skin hospital infections with case agents resistant for antibacterial substances *Escherichia* (E.) *coli*, *Aeromonas* (A.) *hydrophila* and *Staphylococcus* (S.) *aureus* (Dinkov, D., 2017, Perspection of Royal Jelly and Bee Honey as new antibacterial therapy agents of hospital infections, Journal of Clinical Pathology & Laboratory Medicine, Review article, Vol.1, Issue 1., pp. 5-8 <http://www.alliedacademies.org/clinical-pathology-laboratory-medicine/>)

It is proposed interpreting royal jelly, oak honeydew and rape honey concentrations, royal jelly and rape honey (1:100 w/w) combinations as Real Bactericidal Concentrations (RBC) when the 24-hour and 48-hour incubations in enrichment broths specific for respective bacteria and subcultivation on selective nutrient media resulted in lack of a single colony (0 CFU/ml or 100% inhibition). (Dinkov, D., 2021. Microbiological approach for determination of the real bactericidal concentration (RBC) of some types of honey and royal jelly. Bulg. J. Vet. Med., 24, Suppl. 1, 24–29. Suppl. 1, 24–29, ISSN 1311-1477 (print); ISSN 1313-3543 (online)

In the study from 2022 were presented a new data for specific antibacterial activity in mixes between royal jelly and bee honey against resistant for antibacterial substances microorganisms. This could be important for future development of effective drugs for therapy of skin and intestinal infections (Velina Dinkova & Dinko Dinkov, 2022, Royal jelly and bee honey combination - a new perspective for antibacterial therapy of skin and intestinal infections, Tradition and Modernity in Veterinary Medicine, vol.7, No 2(13): 22-29, ISSN 2534-9333, DOI 10.5281/zenodo.7703956)

3.2.3 Thrush Treatment : Application of honey to the infected area can help reduce inflammation and prevent the growth of infection-causing bacteria. Honey has potential as a canker sore treatment due to its antibacterial, anti-inflammatory, and wound healing properties. The use of honey in the treatment of canker sores can provide significant benefits in reducing pain, accelerating healing, and reducing the risk of infection (Lomban et al., 2021).

3.2.4 Resolves Throat Infections and Coughs : Honey consumption can help reduce throat irritation and has antimicrobial effects against pathogens that cause infection. Several studies have shown that the use of red ginger and honey in nursing care for acute respiratory infections in children can provide benefits in overcoming these conditions. (Novikasari et al., 2021). In addition, research by showed that natural honey has inhibition against Streptococcus beta hemolyticus Group A, which is the cause of pharyngitis, indicating the potential of honey in overcoming throat infections (Wineri et al., 2014).

3.2.5 Digestive Support : Honey can help in promoting digestive health. The prebiotics present in it support the growth and activity of good bacteria in the gut, which is essential for healthy digestion. Honey has also been used in traditional medicine for various health conditions, including diarrhea. References mention that honey complementary therapy can help reduce the frequency of diarrhea, accelerate the healing process, and increase body weight in children with diarrhea (Dwi et al., 2022). The use of honey in the treatment of diarrhea is also supported by other studies showing that the combination of honey with ORS can be an effective treatment option.

It is important to remember that although honey has antimicrobial properties, its use should be condition-specific and does not necessarily replace conventional medical treatment, especially for serious wounds or bacterial infections. Always consult a healthcare professional before using honey as an alternative or supplementary treatment. Honey has long been valued not only for its sweet taste and antimicrobial properties, but also for its benefits to the digestive system. The digestive support from honey comes from several unique properties and components:

3.2.5.1 Prebiotic Properties

Honey contains oligosaccharides, which act as prebiotics. Prebiotics are a type of fiber that is not digested by the human body but serves as food for good bacteria (probiotics) in the gut. By supporting the growth and activity of these bacteria, honey can help maintain a balanced gut microbiome, which is essential for good digestive health and a healthy immune system. Research by Hutkins et al. highlighted the complexity of interactions between prebiotic substrates and gut microbiota, suggesting that prebiotics may play a role in promoting gut health. In addition, research by showed that prebiotics in human honey can provide support for the growth of good bacteria such as Bifidobacterium and Lactobacillus (Courvalin, 2006).

3.2.5.2 Reduces Inflammation

Honey has anti-inflammatory properties that can help reduce inflammation in the digestive tract. This can be beneficial for individuals with conditions such as gastritis or inflammatory bowel disease, helping to relieve symptoms and support the healing process. The anti-inflammatory properties of honey provide significant benefits in maintaining health and supporting the healing process. Research by Rahmah (2021) highlighted the antioxidant activity of honey in relation to its anti-inflammatory potential in suppressing the production of peroxides, which function in the inflammatory process. In addition, research by Yaghoobi et al., (2013) showed that honey has anti-inflammatory, anti-bacterial, anti-oxidant, and anti-viral properties, which support the role of honey in the wound healing process.

3.2.5.3 Helps to Heal Ulcers

Thanks to its combination of antimicrobial and wound-healing properties, honey can be used to help heal stomach and intestinal ulcers. It is particularly effective against *Helicobacter pylori*, a bacteria often associated with the development of ulcers and chronic gastritis conditions. Study by Rahmah (2021) highlighted the antiulcer effect of honey in a gastric ulcer model induced by nonsteroidal anti-inflammatory drugs, demonstrating the potential of honey in reducing gastric damage. This study provides valuable insights into the possible use of honey as a complementary therapy to address gastric ulcers induced by nonsteroidal anti-inflammatory drugs.

3.2.5.4 Calming Effect

Honey has a soothing effect on the digestive tract, helping to relieve irritation and protect the mucosal lining of the intestines. This can be beneficial for relieving symptoms such as heartburn or acid reflux. Honey and foods containing prebiotics and probiotics can improve overall digestive health by reducing inflammation in the digestive tract (Mamuaja & Gumolung, 2018)..

3.2.5.5 Increased Nutrient Absorption

Some research suggests that honey may improve the absorption of certain nutrients in the body, such as calcium and magnesium. This might contribute to better bone health and other metabolic functions (Hakim et al., 2021).

3.3 Honey for Digestive Support

3.3.1 As a Natural Sweetener: Replacing sugar with honey can help reduce digestive tract irritation sometimes caused by artificial sweeteners or processed sugar.

3.3.2 Consumed Directly or Dissolved in Water : Eating a teaspoon of honey or dissolving it in a glass of warm water can help calm the stomach and support digestion.

3.3.3 Added to Tea or Yogurt : Honey can be integrated into foods and beverages rich in probiotics, such as herbal teas or yogurt, for combined digestive benefits.

3.3.4 Anti-inflammatory Effects : Honey exhibits anti-inflammatory properties that can help reduce inflammation and provide relief from conditions such as joint pain and inflammatory bowel disease (Rahmah, 2021).

It is important to remember that while honey offers various benefits for digestion, its consumption should be in reasonable amounts, especially for individuals with sugar sensitivity or certain health conditions. As always, discussing with a doctor or nutritionist is the best step before making any significant changes in your diet or health routine. Honey is known to have significant anti-inflammatory effects, which makes it beneficial in reducing inflammation and aiding in the healing of various health conditions. These anti-inflammatory properties come from the unique combination of bioactive components in honey, including antioxidants, such as flavonoids and phenolics, which play an important role in honey's anti-inflammatory mechanism.

3.4 Honey for Anti-inflammatory Benefits

Direct Consumption : Consuming honey directly or adding it to tea can help utilize its anti-inflammatory properties for internal health.

Topical Application : For wounds or skin conditions, honey can be applied directly to the affected area to reduce inflammation and promote healing (Putri & Asparini, 2017).

Integration in Diet : Adding honey to the daily diet in place of artificial sweeteners or refined sugar may help reduce systemic inflammation (Rafie et al., 2018).

Energy Source : Honey is a source of carbohydrates, mainly fructose and glucose, which can provide a quick energy boost. This makes it a good choice for consumption before or after a workout.

It is important to note that although honey has many health benefits, including anti-inflammatory effects, excessive consumption should be avoided, especially by individuals with certain health conditions such as diabetes. Always consult a healthcare professional before making any significant changes in the use of honey for health purposes. Honey is a quick and efficient source of energy due to its unique natural sugar composition, which consists mainly of fructose and glucose. These sugars are easily absorbed by the body, providing an instant and effective energy boost. This makes honey a popular choice among athletes and individuals looking for a natural source of energy to boost physical and mental performance.

Here are some key aspects of honey as an energy source:

3.4.1 Fast Absorption

The glucose in honey is absorbed quickly by the bloodstream, providing an immediate energy boost. Fructose is absorbed more slowly, providing a more sustained supply of energy. This combination makes honey a good source of energy for both quick recovery and long-term stamina. Research by Anggraini and Murbawani (2013) showed that the consumption of honey beverages can increase the blood glucose levels of youth soccer athletes during simulated matches, suggesting that honey has a role as an energy source parallel to glucose. In addition, honey has also been recognized as a source of energy that is highly nutritious and has high medical benefits (Suhandy & Yulia, 2021).

3.4.2 Sustainable Energy

Unlike processed sugars that cause sharp spikes and drops in blood sugar levels, honey provides a more steady flow of energy. This is because the natural blend of glucose and fructose in honey allows the body to regulate energy absorption more efficiently. Research by Lesmana et al.(2018) showed that blood glucose can play a role in providing energy before, during, and after physical exercise, demonstrating the importance of glucose in maintaining the body's energy stability. Various relevant references, glucose and fructose contained in honey have an important role in maintaining the stability of the body's energy.

3.4.3 Muscle Recovery

The carbohydrate content of honey makes it an effective source of energy for muscle recovery after exercise. Consumption of honey after exercise can help replenish glycogen, the main source of energy for muscles, which aids recovery and reduces fatigue. Research by Lesmana et al.,(2018) showed that the administration of honey from various types of bees can affect several biochemical parameters in mice, including blood glucose, lactic acid, and glycogen in muscles and liver, which are important indicators in muscle recovery. Honey can provide fast and lasting energy, and helps in accelerating the muscle recovery process after exhausting physical activity.

3.4.4 Vitamin and Mineral Source

Apart from being a source of carbohydrates, honey also contains small amounts of vitamins and minerals that can support energy metabolism. These include vitamin B6, thiamine, niacin, riboflavin, as well as minerals such as magnesium and potassium. Research by Damayanti and Jannah, (2022) highlighted that honey contains amino acids, carbohydrates, proteins, several types of vitamins, as well as minerals that can be absorbed by body cells. In addition, research by Wibawanti et al.,(2020) showed that honey contains various types of vitamins (such as vitamins B, C, and E) and minerals (such as zinc, iron, calcium, and magnesium).

3.5 Health Benefits of Honey's Anti-inflammatory Effects

Wound Healing : Honey is used topically to accelerate wound healing, including burns, cuts, and chronic wounds such as diabetic foot ulcers, thanks in part to its anti-inflammatory properties (Fuadi & Yanto, 2022).

Skin Diseases : Can be used to reduce inflammation and relieve skin conditions such as eczema, psoriasis, and dermatitis (Lomban et al., 2021).

Pain and Swelling Reduction : Honey may help reduce pain and swelling associated with inflammatory conditions such as arthritis (Rahmah, 2021).

Digestive Health : The anti-inflammatory properties of honey are beneficial in reducing inflammation in the digestive tract, aiding in the treatment of conditions such as gastritis and inflammatory bowel diseases (Rahmah, 2021).

3.5.1 Mechanism of Honey's Anti-inflammatory Effect

Free Radical Reduction : The antioxidants in honey capture and neutralize free radicals, reactive molecules that contribute to the inflammatory process. By reducing the number of free radicals, honey helps reduce oxidative stress and inflammation.

Modulation of Immune Responses : Honey can affect the activity of immune system cells, such as macrophages, neutrophils, and lymphocytes, which play a role in inflammatory reactions. By modulating these activities, honey can reduce the production of pro-inflammatory cytokines and other inflammatory mediators.

Reduction of Inflammation in Tissues : With anti-inflammatory and antimicrobial properties, honey helps in wound healing and reduces inflammation in injured or infected tissues.

4. Usage and Considerations

While honey has many health benefits, it is important to consume it in moderation due to its high sugar and calorie content. People with certain health conditions, such as diabetes, should consult a doctor before significantly adding honey to their diet. Also, raw honey should not be given to infants under one year old due to the risk of botulism. In a nutraceutical context, honey can be considered a superfood that not only provides essential nutrients but also offers a range of health benefits that support its use as a natural treatment and general health booster. The recognition of honey as a nutraceutical emphasizes the importance of natural food sources in supporting health and well-being.

CONSENT (WHERE EVER APPLICABLE)

chapter book that has been created There is no consent by the authors

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

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APPENDIX

there are no attachments to this manuscript

UNDER PEER REVIEW